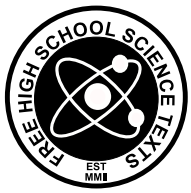

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The Free High School Science Texts: Textbooks for High School Students Studying the Sciences Physics Grades 10 - 12

Version 0
November 9, 2008

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Contents

Part VI

Essays

Essay 1: Energy and electricity. Why the fuss?

Author: Asogan Moodaly

Asogan Moodaly received his Bachelor of Science degree (with honours) in Mechanical Engineering from the University of Natal, Durban in South Africa. For his final year design project he worked on a 3-axis filament winding machine for composite (Glass re-enforced plastic in this case) piping. He worked in Vereeniging, Gauteng at Mine Support Products (a subsidiary of Dorbyl Heavy Engineering) as the design engineer once he graduated. He currently lives in the Vaal Triangle area and is working for Sasol Technology Engineering as a mechanical engineer, ensuring the safety and integrity of equipment installed during projects.

Disclaimer: The details furnished below are very basic and for illustration purposes only.

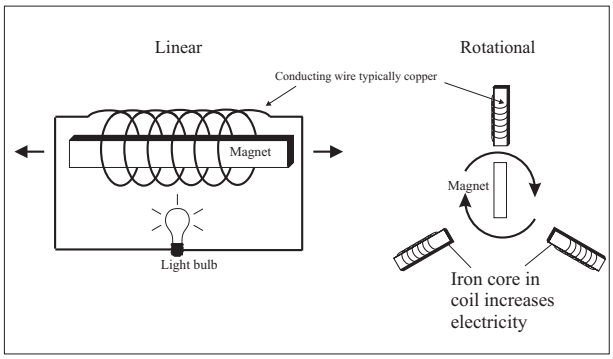
Why do we need energy? Note that I use the word 'energy' and not 'electricity'. On a broad scale it stimulates economic growth, etc, etc but on a personal level it allows us to lead a comfortable lifestyle.

e.g. Flick a switch and

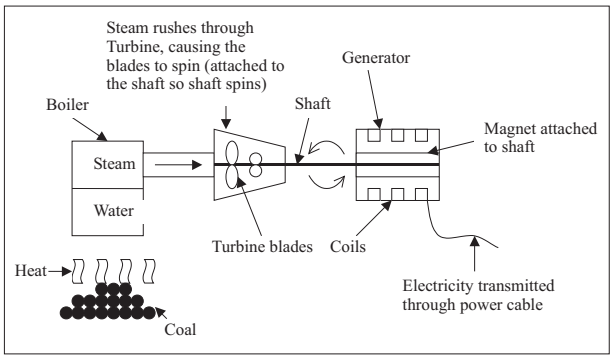
- Heat for cooking
- Entertainment such as television and radio
- Heat for water and interior of house
- Ironing
- Electronic and electrical devices such as alarms, garage doors, etc.

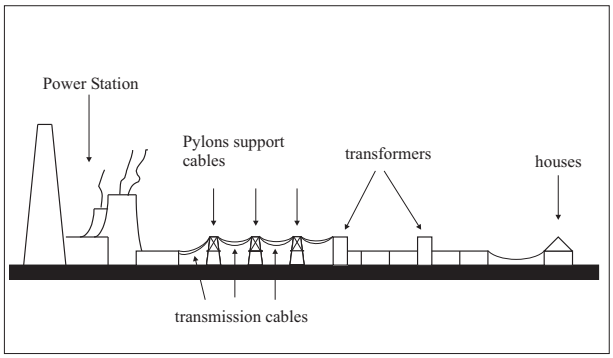
In a modern household this energy is provided in the form of electricity which is powered via fossil fuels or nuclear.

How is electricity made? In a nutshell: By moving a magnet through or near a set of conducting coils.



Most power stations produce steam through heat (nuclear reaction or burning fossil fuels), the steam drives a turbine which moves a magnet relative to a coil (the generator - like the above but on a much larger scale i.e. bigger magnets, bigger coils, etc), which produces electricity that is transmitted via a power network to our homes. Gas fired plants burn gas directly in a gas turbine to produce the same desired relative motion between permanent magnet and coil.





Coal, oil and gas are fossil fuels. Fossil fuels were created by decomposing organic (plant and animal) matter a long, long time ago and are typically found underground. Different temperatures and pressures resulted in the organic matter transforming into coal, oil or gas.

Why the fuss about fossil fuels?

1. Fossil fuel power is bad news in the long run. It pollutes and contributes to the greenhouse effect (global warming resulting in melting polar ice caps, floods, droughts, disease, etc).

2. It's not going to last forever.

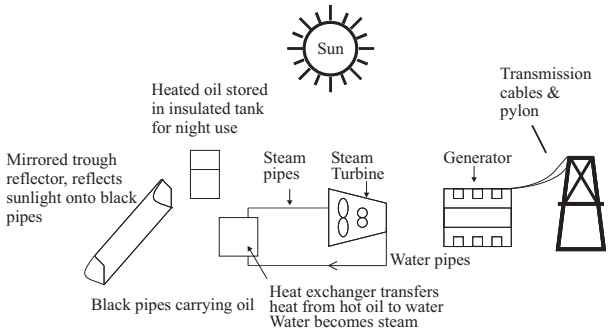
3. Nuclear power is 'cleaner' in terms of emissions but there's no proven way of disposing of the nuclear waste. Oh, and it won't last forever either!

Renewable Energy As the name suggests renewable energy lasts 'forever'. Solar (sun), wind, geothermal, wave, hydro and biomass (organic) are all sources of energy that will last until the sun eventually explodes many millions of years from now. Hopefully the human race will have moved from the earth by then! Generally the principal of renewable electricity generation is similar to fossil fuel electricity generation in that electricity is generated by moving a magnet relative to a conducting coil. What is different is the way energy is supplied to cause that motion.

The below are a few different types of available renewable energy technologies.

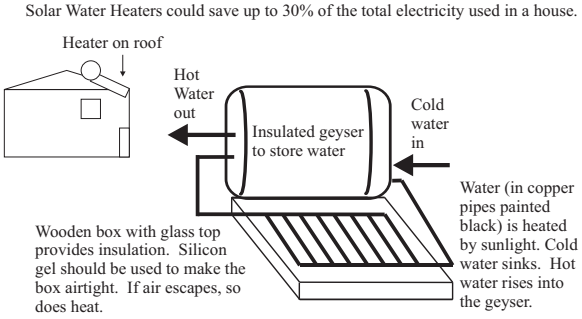
Solar

There are different types of solar electricity technologies, the main ones being solar thermal and photovoltaic.



Solar thermal uses the heat of the sun to produce electricity. Sun is concentrated using mirrors. This heat either creates steam which drives a turbine which in turn drives a generator (as per fossil fuel generation), or drives an air engine (engine that uses expanding air to obtain motion) that drives a generator.

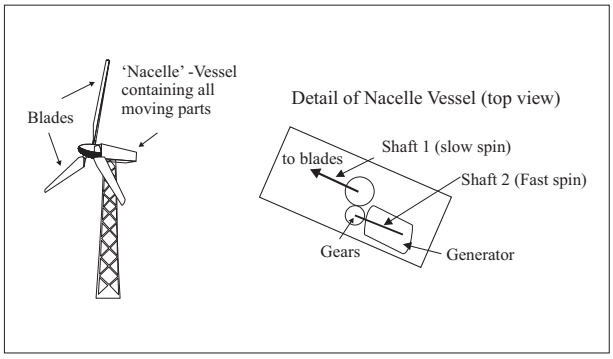
Photovoltaic panels convert sunlight directly into electricity. The benefit of photovoltaic panels is that there are no moving parts, and is therefore relatively maintenance free. The downside is that it's very expensive at this stage (17/06/2004).



Wind

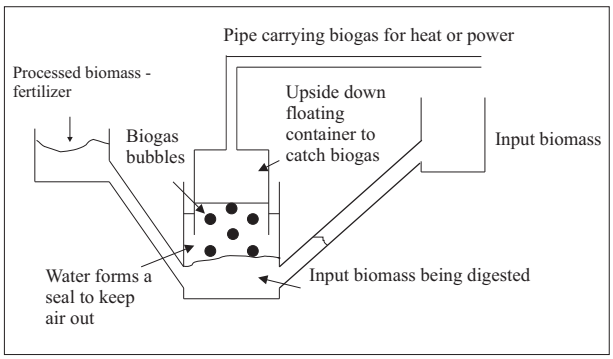
Wind turbines catch wind that spins the blades. The blades are connected to a shaft that spins because of the wind. This spinning shaft spins another shaft that turns a permanent magnet relative to conducting coils.

Note that 'gears' are used to convert the slow spinning of the 1st shaft to a faster spin on the 2nd shaft. The generator shaft needs to spin at the correct speed to produce the right amount and quality of electricity. Some generators are now being modified to run at slower speeds. This saves money as gears are not needed.



Biomass

Biomass is anything organic i.e. plant or animal matter. It can be used in the place of coal as per a normal coal fired plant and is renewable as long as the biomass e.g. wood; is handled in a sustainable manner. By sustainable I mean that suitable farming practices are used so that the land is not 'over farmed' which will result in the soil becoming barren and nothing growing there again.



Biomass can also be processed using 'anaerobic digestion' to produce a gas that can be burned for heat or electricity. This 'biogas' is made up of a number of other gases that are similar to those found in fossil fuel natural gas - Except the amount of the gases are different. E.g. Natural gas has about 94

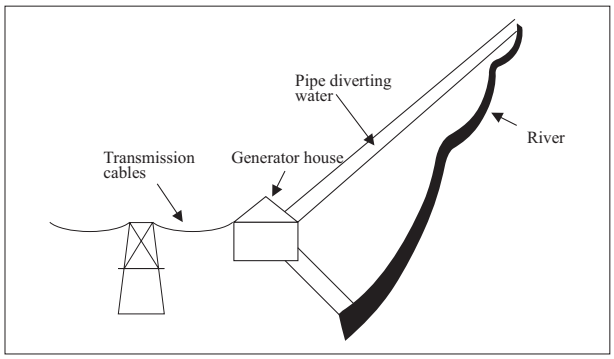
Anaerobic digestion: 'Anaerobic' means 'No air'. Therefore 'anaerobic digestion' means to digest in the absence of air. Bacteria that naturally exist in organic matter will convert organic matter to biogas and fertilizer when all the air is removed.

Thousands of anaerobic digesters have been installed in rural India, Nepal and China in rural area's where cow dung, human waste and chicken litter (faeces) are all processed using anaerobic digestion to produce gas that can be burned in the home for cooking and heating. The leftover is used as fertilizer.

Geothermal Energy

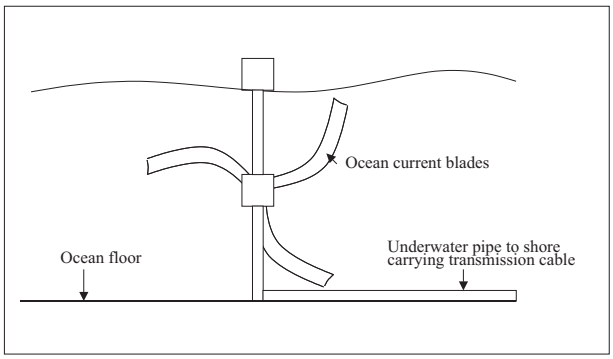
In some places on earth, the earth's crust is thinner than others. As a result the heat from the earth's core escapes. The heat can be captured by converting water to steam, and using the steam to drive a steam generator as discussed above.

Hydroelectric power Water from a river is diverted to turn a water turbine to create electricity similar to the principles of steam generation. The water is returned to the river after driving the turbine.

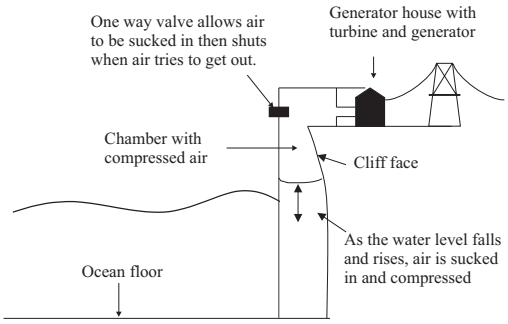


Wave Energy

Some wave energy generators work similarly to wind turbines except that underwater ocean currents turns the blades instead of wind; and of course most of the structure is under water!



Another concept uses the rising and falling of the tides to suck air in using a 'one way valve'. As a result air becomes compressed in a chamber and the compressed air is let out to drive a turbine which in turn drives a generator



These are relatively new technologies.

Liquid Fuels Liquid fuels are used mainly for transportation. Petrol and diesel are the most common liquid fuels and are obtained from oil.

Sasol is the only company in the world that makes liquid fuels from coal; and will be one of the leading companies in the world to make liquid fuels from natural gas! The Sasol petro-chemical plants are based in Sasolburg on the border of the Free State and in Secunda in Mpumalanga.

However, as discussed above coal, gas and oil are fossil fuels and are not renewable. Petrol and diesel are obtained from fossil fuels and therefore pollute and contribute to the green house effect (global warming).

Alternatives

Biodiesel

Oil can be extracted from plants such as the soya bean, sunflower and rapeseed by pressing it through a filter. This oil if mixed correctly with either methanol or dry ethanol and Sodium Hydroxide will separate the plant oil into biodiesel, glycerol and fertilizer.

The biodiesel can be used as produced in a conventional diesel engine with little or no modifications required.

The glycerol can be refined a bit further for pharmaceutical companies to use, or can be used to make soap.

Ethanol

Corn, maize and sugar cane can be used to make ethanol as a fuel substitute for petrol. It's made by the same fermentation process used to make alcohol. Enzymes are often used to speed up the process.

In ethanol from sugar cane production, the leftover 'bagasse' (the fibre part of the sugar cane) can be burned in a biomass power station to produce electricity.

Hydrogen

Through the process of 'electrolysis' electricity (hopefully clean, renewable electricity!) can split water into hydrogen and oxygen. The stored hydrogen can be used in a 'fuel cell' to create electricity in a process that is opposite to electrolysis; to drive electric motors in a car. The hydrogen can also be burned directly in a modified internal combustion engine. In both cases the 'waste' product is water.

Chapter 33

Essay: How a cell phone works

Chapter 34

Essay: How a Physiotherapist uses the Concept of Levers

Chapter 35

Essay: How a Pilot Uses Vectors

How an air traffic controller uses radar

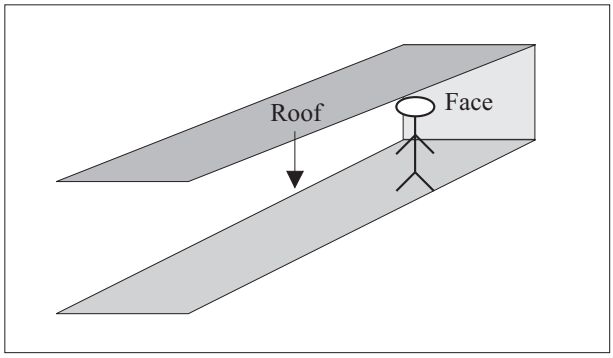
How sonar is used for fishing

Asogan Moodaly received his Bachelor of Science degree (with honours) in Mechanical Engineering from the University of Natal, Durban in South Africa. For his final year design project he worked on a 3-axis filament winding machine for composite (Glass re-enforced plastic in this case) piping. He worked in Vereeniging, Gauteng at Mine Support Products (a subsidiary of Dorbyl Heavy Engineering) as the design engineer once he graduated. He currently lives in the Vaal Triangle area and is working for Sasol Technology Engineering as a mechanical engineer, ensuring the safety and integrity of equipment installed during projects.

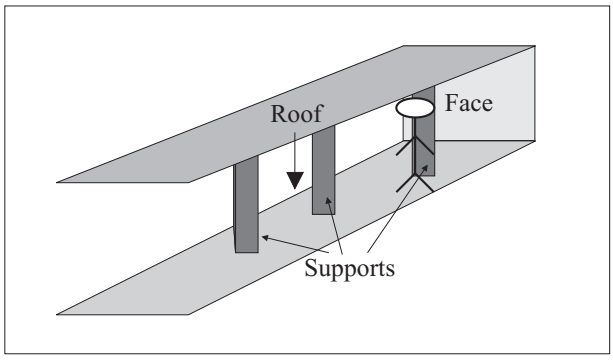
Pressure and Forces

In the mining industry, the roof (hangingwall) tends to drop as the face of the tunnel (stope) is excavated for rock containing gold.

As one can imagine, a roof falling on one's head is not a nice prospect! Therefore the roof needs to be supported.

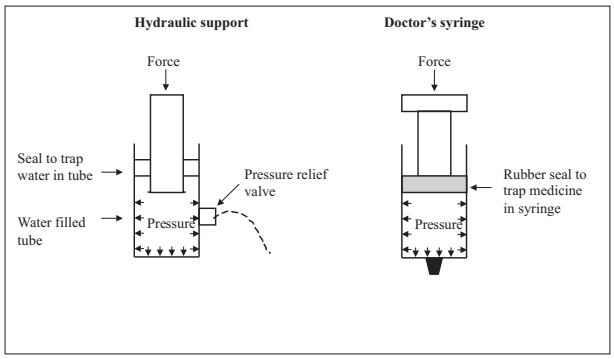


The roof is not one big uniform chunk of rock. Rather it is broken up into smaller chunks. It is assumed that the biggest chunk of rock in the roof has a mass of less than 20 000 kgs therefore each support has to be designed to resist a force related to that mass. The strength of the material (either wood or steel) making up the support is taken into account when working out the minimum required size and thickness of the parts to withstand the force of the roof.

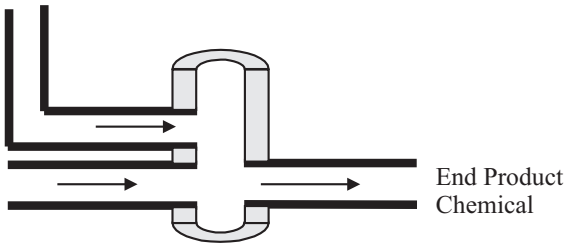


Sometimes the design of the support is such that the support needs to withstand the rock mass without the force breaking the roof..

Therefore hydraulic supports (hydro = water) use the principles of force and pressure such that as a force is exerted on the support, the water pressure increases. A pressure relief valve then squirts out water when the pressure (and thus the force) gets too large. Imagine a very large, modified doctor's syringe.



In the petrochemical industry, there are many vessels and pipes that are under high pressures. A vessel is a containment unit (Imagine a pot without handles, that has the lid welded to the pot that would be a small vessel) where chemicals mix and react to form other chemicals, amongst other uses.



The end product chemicals are sold to companies that use these chemicals to make shampoo, dishwashing liquid, plastic containers, fertilizer, etc. Anyway, some of these chemical reactions require high temperatures and pressures in order to work. These pressures result in forces being applied to the insides of the vessels and pipes. Therefore the minimum thickness of the pipe and vessels walls must be determined using calculations, to withstand these forces. These calculations take into account the strength of the material (typically steel, plastic or composite), the diameter and of course the pressure inside the equipment. Let examine the concepts of force and pressure in further detail.

Appendix A

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